ART. VI.—*On the Structure of the Alimentary System of Gryllotalpa australis (Erichs.), with some Physiological Notes.*

By O. A. SAYCE.

(With Plates IX. and X.)

[Read 14th July, 1898.]

I desire to acknowledge my indebtedness to Professor W. Baldwin Spencer for kindly interest and help during my investigations; also, I am under obligation to Mr. T. S. Hall, M.A., who has supplied me with references and books; to Mr. T. E. Edwards for helpful literature; and to Mr. J. A. Kershaw of the National Museum, for the identification of the species.[1]

The common Victorian species of mole-cricket *Gryllotalpa australis*, Erichs., differs in the alimentary system, in no marked degree, from *G. vulgaris*, Ltr. The size of the insect is, however, smaller; the usual length of *G. australis* being 32 mm., and that of *G. vulgaris* 52 mm.

G. australis abounds very plentifully in gardens and meadow lands for some miles around Melbourne and other parts of Victoria, and may readily be traced to their burrows at sunset, in summer and autumn, by the strong shrill noise of the males. Only the females can fly.

Other localities recorded for this species, Mr. Kershaw informs me, are New South Wales, Queensland, and the Islands of Ceram, and New Caledonia. He has no record of their being found in Tasmania. Further, I hear from him that there are at least three species of the genus found in Australia.

As is well known, Gryllotalpa is omnivorous, but as far as our species is concerned, Mr. Charles French, Government Entomologist of Victoria, tells me that he has only had two reports of its destruction of root crops. I have kept them alive for months

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1. During the passage through the press of this paper I have had the opportunity of consulting Professor A. S. Packard's Text Book of Entomology (Macmillan, 1898). Wherever possible I have adopted his terminology.

with a diet of earth worms and insects, which they devour greedily, while such things as potatoes and bulbs remain untouched. Local conditions however, might affect their preference.

The Alimentary Canal.

The alimentary canal is richly supplied by tracheæ, which wrap themselves round the various organs and convolutions, and ramify among the muscles. They form the principal support of the digestive organs in the body cavity (hæmocœle).

I shall enumerate the embryonic divisions of the canal and then describe its structure—

Classification of Embryonic Divisions and Parts.

It comprises three main divisions:—

1. *The Fore-intestine*, which is of ectodermic origin and corresponds to the stomodæum of the embryo, includes the mouth, salivary glands, pharynx, fore-gullet, crop (ingluvies) hind-gullet and proventriculus (gizzard). On account of dissimilar structure I have considered it necessary to divide the œsophagus into fore- and hind-gullet; the fore-gullet embraces the part between the pharynx and its opening into the crop, and the hind-gullet the part from the outlet of the crop to the entrance of the proventriculus.
2. *The Mid-intestine*, formed from the mesenteron, is remarkably short in Gryllotalpa compared with other of the Orthoptera, and comprises only the cæcal organs. In this I follow Cuénot (2) who differs from other writers, notably Bordas (1) of later date, who have placed the division a little anterior to the entrance of the duct of the Malpighian tubes. I shall state my reasons for so doing later.
3. *The Hind-intestine* (part of which is called mid-intestine by other writers than Cuénot) corresponds to the proctodæum. I divide this into (*a*) fore, (*b*) mid, (*c*) hind terminal canal, (*d*) rectum and (*e*) anus.

It possesses two diverticula, viz., two pairs of arborescent glands (Dufour), and the urinary or Malpighian tubes.

Salivary Glands.

A detailed description of the Salivary Glands of *G. vulgaris* is given by Bordas (1). There is no fundamental difference in *G. australis.* Briefly stated they are composed of two pairs of bunches of lobules, and two thin walled and extensible reservoirs. The smaller efferent ducts, and the ducts from the reservoirs, open into main ducts, which traverse the prothorax on each side of the œsophagus, pass below the ganglia, and meet to form a very short common duct that opens behind the lower lip and under the lingua. Of the two pairs of bunches of gland cells, the anterior pair, located in the mesothorax, is the smaller; they in part meet and surround the œsophagus.

The posterior pair, situated principally in the metathorax, is larger, and, in contrast with Bordas's experience, I have generally found them to stretch as far back as the second abdominal segment, a little anterior to the testes.

The cells of the alveoli are surrounded by a thin cellular membrane. The nuclei of the secreting cells are large (25μ) and possess numerous nucleoli.

The whole of the glands and ducts originate from the ectoderm.

Fore-gullet.

The fore-gullet, leading from the pharynx passes through the occipital foramen and following a straight course through the thorax opens, at a distance of 14 mm., into the crop. When not distended by food its lumen is closed by deep longitudinal folds, but it is capable of very wide distension. Its outer wall (Fig. 2) is composed of annular and longitudinal muscle fibres (I have not determined a peritoneal layer), overlying a thin basement membrane, upon which reposes a single layer of cubical epithelial cells with large nuclei; these secrete a thick layer of hyaline chitin, bordered by strong yellow chitinous denticulations. These teeth (Fig. 2*a*), are ·2 mm. in length, laterally much compressed, and terminate at the summit in one or more fine points. They are acutely bent at their base, and point backwards, so that they overlap one another like tiles on a roof.

Crop.

The crop or ingluvies, into which the fore-gullet opens, is a large ellipsoidal thin-walled sac, situated in the thorax. When fully distended it measures about 6 or 7 mm. at its widest diameter. In contrast to other of the Orthoptera it is situated on one side of the axis of the digestive tube. It may be considered as a large lateral expansion of a part of the wall of the œsophagus, the opposite portion of the wall continuing posteriorly for about ·5 mm., when it is met by the return of the wall of the crop to form the posterior outlet of that organ.

The histological elements are the same in kind as those of the œsophagus. In contra-distinction, its wall is much thicker, due in part to the epithelial cells which are columnar shaped, and also to the cuticle, which is thicker. The musculature is similar, viz., thin bands of muscle fibres crossing one another. The teeth are much shorter, each terminating in a point, and they project inwards like teeth of a saw, and are arranged to form rows side by side in close juxtaposition. The surface thus presents an appearance something like a rasp.

When the crop is not fully distended by food the epithelial and chitinogenous layers are thrown into deep corrugations, which radiate from the openings, and when further emptied the whole wall is deeply folded, and the organ presents a much shrivelled appearance.

Both at the anterior opening and posterior outlet the annular muscles of the gullet are much more numerous, and valves are formed by cushions on the inner wall. If inflated with air and then dissected out, I have found that only a small quantity of air escapes, the organ remaining considerably distended, which demonstrates how effectually the inlet and outlet may be closed.

Hind-Gullet.

This commences at the outlet of the crop and continues for a short distance (4 mm.) when it rapidly widens in the formation of the gizzard.

The annular muscles of this portion of the canal are more numerous than in the fore-gullet, and the wall is consequently not so distendable.

The cuticle is raised into more decided longitudinal anticlinal folds, and the whole is fringed by long fine chitinous setæ, pointing backwards; very different in structure from those of the fore-gullet.

Proventriculus or Gizzard.

The Proventriculus or gizzard is spheroidal in shape, and measures about 3·5 mm. through its long axis. It is united with the posterior end of the hind-gullet, leading from the crop. At the orifice the walls of the food-canal are raised into definite cushions, which unitedly act as a valve to close the gizzard and prevent a retrograde movement of the food.

The outer wall at the hinder extremity is reflected and joins with two cæcal organs (the mid-intestine); the inner chitinous layer is continued to form four membranous curtains, the œsophageal valve of Weismann, which hang loose and function as guards to prevent the entrance of coarse food material into the cæca.

A median transverse section of the gizzard (Fig. 4) reveals the presence on the outside of (*a*) a very thick layer of annular muscle fibres, underlying which are (*b*) longitudinal muscle fibres comparatively few in number; (*c*) a basement membrane, on which is situated (*d*) a layer of chitinogenous cells, which secrete varying thicknesses of chitin, forming strong and elaborately shaped teeth and setæ. The teeth are situated upon folds of the inner wall, and they form six definite columns, each column being similar in structure. Each column is transversely divided as far back as the radial wall by generally fourteen or fifteen definite, but irregular radial ridges, which are disposed longitudinally one underneath the other, and separated by very short distances (Fig. 3).

The appearance of a transverse section of the gizzard, showing one of these columns cut across, with the upper or anterior surface of one-sixth part of a radial ridge uppermost, is shown in Fig. 4. Each part of the ridge is similar; it will be unnecessary to describe more than one to represent the whole. They are each bilaterally symmetrical. A central fold projects into the cavity of the gizzard for a distance of ·4 mm., capped by strong yellow chitin, bearing teeth, and spreading laterally at the summit to ·3 mm. The depth across the face, at the summit, from the upper to the under border measures ·7 mm. The centre at the summit is concave on the upper surface, and underneath is a thin lip curving somewhat upwards with four or five strong pointed teeth which project a short distance into the cavity of the gizzard (Fig. 4, M.T.). On each side of this branch two very short chitinous extensions, similar to each other, with flat surfaces, having short blunt points scattered over the surface (Figs. 4 and 5, M.T.A.). They are directed laterally with their under or posterior border fringed with four strong pointed teeth projecting outwards and curving upwards. This, as a whole, we may call the median tooth.

On each side of the lateral extensions of the median tooth are two large paired teeth, which arise from the middle fold, but nearer the radial wall and project further into the cavity of the gizzard (Figs. 4 and 5, L.T.). As each tooth arises from its base it points laterally, but curves round and upwards in a half spiral turn, to point towards the centre; thus they are more anterior in respect to the opening of the gizzard than the lateral extensions of the median tooth, and also more lateral. These lateral teeth have the under surface flat and broad, and clothed with little blunt points (Fig. 5), and this surface faces the flat surface of the appendages of the median tooth to unitedly form an obtuse angle, divided by a small space. The opposite or upper surface (Fig. 4) is rounded and possesses a row of pointed projections directed inwards, and each tooth tapers towards the apex. They are united by a band of chitin.

Longitudinal muscles follow the fold inwards for some distance.

Fringing the sides of this median fold, and hanging down somewhat underneath are chitinous membranes clothed with long fine setæ pointing towards the centre, and on each side of these arise from the radial wall two projections, with the appearance of a bluntly-pointed apex when viewed from above, as shown in the section, but they are membraneous, and the wall of each bends over downwards. They are clothed with setæ pointing centrally.

Lateral to these again are two smaller projections with depressed summits, the centre of which marks the lateral extremity of one-sixth part of the whole ridge, and from whence, on each side, commence similar parts of the same radial ridge. These lateral projections are not transversely divided, but run uninterruptedly from the anterior to the posterior extremity of the columns (Figs. 4 and 6, P.).

It must be remembered that the whole of the inner cuticle of the gizzard is strongly chitinous.

The anterior eleven or twelve transverse ridges (they vary in number) in the main agree with the foregoing description, and occupy a distance conjointly of 2 mm. Considered as a whole in relation to their shape, position, and the muscle fibres, one is justified in considering these teeth as capable of mastication to some extent, and this is achieved, I believe, by the lateral faces of the teeth of the central fold working against similar teeth in the next parts of the ridge on each side, and so incision and crushing is brought about. Further, owing to their shape, and also to the aid of the setaceous projections, briefly mentioned, the finely triturated food is separated from coarse material, which is kept in the centre of the organ, and conveyed to longitudinal channels which run along the radial wall between the lateral folds, and become more pronounced towards the posterior. These I call food-pulp channels (Figs 3 and 6, F.P.C.).

A transverse section, taken a little below the chitinous teeth, at the part marked 4 in Fig. 3, is shown in Fig. 6, the ridges of the six longitudinal columns, previously considered, will be seen to have changed in structure, they have no strong chitinous teeth, but the folds are covered by thin cuticle, clothed with fine setæ. The parts are not all alike, two, side by side, are similar to other two that are diametrically opposite, while the remaining two are quite different, but each is like the other, and they are situated opposite to each other. The food-pulp channels are here very conspicuous, and are seen to be guarded by projections and flaps, clothed with setæ, which act as guards to prevent the marc, or coarse food residue, which is kept in the centre of the gizzard, from gaining entrance to them. Tracing these food-pulp channels to the posterior outlet they are found to turn into the cæca, and deflect upward for a short distance (Fig. 3). Six enter one cæcum and the remaining six the other.

The coarse food material is allowed to pass directly through the centre of the gizzard, but is prevented by four chitinous membraneous curtains (which hang down as far as the commencement of the fore-terminal canal), from gaining entrance to the cæcal organs, so that its delicate walls, which are unguarded by any chitin, are not injured.

Hepatic Cæca.

The hepatic cæca (mid-intestine) are two paired, oblong, and slightly concave organs, measuring 6 mm. through their long axis, and are situated one on each side of the gizzard, and in part attached to its wall (Figs. 1*a* and 3). The anterior of each terminates in a blunt point, a little more forward than the commencement of the gizzard and their posterior end stretches about 2 mm. behind the extremity of the gizzard. The wall lying next to the gizzard is concave, and this wall in each unites with the reflected hinder extremity of the gizzard, and the two cæca entirely surround it. The opposite lateral wall, that is the one of greater curvature, of each, extends posteriorly and joins the anterior extremity of the terminal intestine and entirely surrounds it; the remainder of the otherwise unattached walls of each, incurve, and unite with each other in the mid-axis, dorsally and ventrally.

In the lateral wall nearest the gizzard, the cellular layer forms two or more deep longitudinal folds, which project for some distance inwards, and enclose tracheæ. The internal surface area is consequently very considerably increased.

The histological structure is similar in each cæcum. There is no chitinous intima. The wall is sparingly supplied with radiating and transverse muscles, and next to these on the inner side is a thin layer of connective tissue, upon which are situated the cell elements. At close intervals, about ·1 mm., the connective layer projects slightly inwards, and between these projections are little chambers or nests, each with a rounded base. These are filled with cells which are supported in a fine reticulum, very apparent in a section cut across the cell nests (see Figs. 7 and 8).

Upon the projections of the connective tissue are long cylindrical epithelial cells with filamentous free border; they taper towards the attached end, and overarch the cell nests, leaving only a small opening, difficult to determine, which serves as a passage for the cells of the nests, or their secretions into the cavity of the organ.

The cell-nests are composed of young cells at the base, crowded together, which stain deeply; they gradually become matured towards the opening between the filamentous cells. I have considered the probability of these cell-nests being germinative centres containing young cells of the epithelium which overarches them, but their dissimilar appearance as they reach maturity, their greater number than the cylindrical cells, and also their position in relation to them, has convinced me of the improbability of such being the case.

The Terminal Canal.

This is joined to the posterior extremity of the cæca, and after describing several round turns in the body-cavity, ends at the anus. It is necessary on account of structural differences to divide it into fore-, mid-, hind-, terminal canal, and rectum. Except Cuénot, other writers have considered the mesodermal middle intestine to extend as far back as a little anterior to the entrance of the duct of the Malpighian vessels, and although this is so, I believe, in other of the Orthoptera, in Gryllotalpa there is no reason for so doing, for there is no marked differentiation of the cell-wall at this part. The musculature, however, changes sharply which gives an altered appearance from the outside. Further, the outer and inner muscle layers are both striated, which is not in accord with Professor Packard's description of the histology of the mid-intestine,[1] and there extends a chitinous intima throughout the whole of the passage.[2] The muscles surrounding the wall are reversed in order compared with the anterior canal, so that the longitudinal fibres are outside the annular muscles.

The Fore-Terminal Canal.

This is 4 mm. long, and is surrounded by a thick layer of annular muscles, with the exception of a small anterior portion.

1 *Loc. cit.*, p. 316.

2 *Loc. cit.*, p. 302.

Its wall is thrown into deep longitudinal folds, and the lumen is capable of being closed.

At the anterior limit its wall forms a decided radial fold, projecting inwards as a ridge, after which it joins with the cæcal organs (Fig. 9).

As this junction is approached the cellular wall is free from muscles, and gradually widens like a funnel, and within this widened space the ends of the œsophageal valve lie.

The cuticle covers the cells from the commencement, and almost immediately is beset with short setæ, which point posteriorly, and continue as far as the mid-terminal canal.

At the posterior extremity, the strong bands of annular muscles cease, and the wall suddenly dilates to a width of about 1·5 mm., which marks the commencement of the mid-terminal canal. At the opening, loose folds of the wall of the fore-terminal canal project into the mid-terminal canal for a short distance, which act as valves to prevent a retrograde movement of the food material.

The Arborescent Organs of Dufour.

These are four very small bunches of minute dichotomously branching colourless tubes, forming a dorsal and ventral pair. An efferent duct from each bunch opens into the fore-terminal canal, on the anterior ridge just mentioned.

Cuénot has satisfied himself that they do not play any part in intestinal absorption, nor secrete any digestive fluid. He considers them to be excretory organs, eliminating a product made, doubtless, in a very small quantity. I venture to suggest that the product may be of use for the purpose of neutralizing the acid digested food residue from the cæca.

The Mid-terminal Canal.

This which is the "chylific stomach," ventriculus or mid-intestine of other authors measures 13–15 mm. in length, and its width at the commencement, when distended by food, is 1·5 mm., but it becomes gradually narrower as it unites with the hind-terminal canal. In its course it describes a full round turn in the body-cavity.

The cell wall is composed of a single layer of epithelial cells, and the tunica propria is surrounded by scattered radial and longitudinal muscle fibres. The general shape of the cells is columnar, but in parts they are cubical, and the whole internal face is covered by a very thin hyaline cuticle. The cell-wall frequently leaves the muscular bed and infolds transversely and longitudinally, thus forming little spaces where I have sometimes found "wandering" blood cells. Normally, the blood would always be present in these spaces, but unless entangled among the muscles or tracheæ, any cells would be lost in the preparation of sections.

On the ventral floor of the posterior two-thirds there is a fundamental change of structure; the epithelial cells are altogether wanting, and there exists only a thin nucleated structureless membrane, over which the cuticle lies. This area is much wrinkled, and here and there are short longitudinal folds, forming low ridges, which rise into the lumen, with spinous processes pointing posteriorly; also there are villi of varying length, which at first are few and scattered, but gradually become crowded together towards the narrower end of this part of the canal. These villi (Fig. 10) have the appearance of minute fox-tails, which stretch into the lumen; they vary in length somewhat, but generally are about ·25 mm. long. They are formed by ingrowth, or invagination of the chitinogenous layer, with the result that little hollow finger-shaped crypts or follicles are formed, into which the blood can enter. Each villus has several deep radial folds or pleats, with their anticlinal axis bordered with spinous processes which project into the cavity of the canal, and between these folds are consequently little furrows into which the digested food material can enter, but the granular material is prevented from so doing by the spinous guards.

However, I have not proved that they function in this manner. I have observed "wandering" blood cells in their cavity (Fig. 11), but whether they carry excretory products, or receive digested food, I am unable to definitely say.

The termination of the villous area marks the posterior limit of the mid-terminal canal.

Hind-Terminal Canal and Rectum.

These two, the first of which forms the hind-intestine of other authors, I will consider together. At its union with the mid-terminal canal the lumen becomes narrower, and the radiating and longitudinal muscles more numerous; they are separated at short distances, and the cell-wall between projects outwards to form little protuberances; the cells at these places are larger, and possess large granular nuclei. Viewed on the face, from the inner cavity, they appear as little caverns.

Towards the rectum the lumen widens, and a large cylindrical sac, 5 mm. long (the rectum), is formed, which becomes constricted towards the anus.

In this organ there are six definite longitudinal folds, lined with glandular cells, forming the so-called Rectal glands; they are transversely divided in places. The cuticle overlying these glands I have found to be fenestrated, the openings averaging ·075 mm. in diameter. About mid-way in the rectum there are four large caverns ranged radially round the wall, in which I have noticed, in fasting insects, large crystals adhering to the wall, which I take to be a nitrogenous salt that has crystallized out from material conveyed from the Malpighian tubes.

Malpighian Tubes.

These are fine, flexuous tubes about 14 mm. long, which ramify in the body-cavity. At their attached end they open into the dilated extremity of a common efferent canal (ureter) which, at a distance of 5 mm., enters close to the anterior extremity of the hind-terminal canal. As described and figured by Bordas, (1) the ureter at its junction with the canal protrudes for a short distance to form a neck.

It was at first pointed out by Leydig that there are, in Gryllotalpa, two kinds of tubes, Yellow and White. The white tubes are very few in number, and are peculiar to Gryllotalpa; they are usually crammed with ovoid concretions of uric acid. The yellow tubes are very numerous, and their cells show within them little spherical yellow grains, and occasionally dark brown acicular crystals.

For description of these and other excretory organs, the valuable work of Cuénot (2) should be consulted.

Physiological Notes.

Perhaps no one has done so much experimental work to explain the functions of digestion and assimilation in insects as Plateau, and I regret not having had an opportunity of reading all his papers. I am indebted to the writings of Miall and Denny (3), and also to those of Cuénot (2), for summaries of his work, and to the latter for a resumé of the researches of other notable workers and of his own. It is generally accepted, I think, that the digestion of starch and sugar is effected in the crop by secretions from the salivary glands; that the secretions of the cells of the middle intestine, (those of the cæca playing a predominent part), transform the albuminoids into peptones, and also that fats are emulsified there.

I can find no proof that there is any secretion to split fats into fatty acids and glycerine outside the cells,

Difference of opinion exists as to where absorption and assimilation take place. Plateau and Jousset de Bellesme state that absorption takes place in the crop, the middle intestine, and even part of the terminal intestine. Cuénot (2) states that it is improbable, considering our present ideas on osmosis, that there can be the least absorption into the crop and terminal intestine, for both of them are covered by an impenetrable chitinous cuticle.[1] He further states that in the middle intestine alone and its diverticula, all the absorption is carried on, viz., that of the soluble products, peptones, glucose, and also fats.

For the purpose of determining this, I made some experiments, which prove that osmosis can take place, both in the chitinous lined crop and terminal canal.

To demonstrate this I employed the following methods:—

On three separate occasions I exposed the alimentary canal, and carefully ligatured it, 1st, at the commencement of the mid-terminal canal, and 2nd, at the posterior end, just anterior to the entrance of the ureter; also the œsophagus, at places, to close the passages to and from the crop. I then cut away the closed mid-terminal canal, and also the crop, and suspended them in a 5 per cent. solution of magnesii sulphas for two hours, after which, one at a time, they were thoroughly washed in three separate basins of

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1 *Loc. cit.*, p. 306.

distilled water, opened, and the contents of each placed in watch-glasses (the organs being discarded), distilled water added, then filtered, and the filtrate evaporated, and examined microscopically for amount of crystals, and also chemically tested. The result of each examination was the finding of an amount of magnesia sufficient to prove that osmosis had taken place. The third basin of water used for the final washing of the organs was chemically tested, without showing any appreciable amount of magnesia.

My conclusion regarding the digestion and assimilation of Gryllotalpa, based upon the experimental work of others, and my own, both physically and structurally, is :—

1. That the salivary glands secrete an amylolytic and inversive ferment, which mixes with the food in the crop (Plateau) and that absorption of the glucose can take place in that organ by the epithelial cells, which pass it on to the blood. (Vide experimental proof ante).
2. After a longer or shorter time the food is passed on and enters the gizzard, where it is squeezed, and probably to some extent masticated. In the squeezing the pulp is collected in the open food-pulp channels, which convey it into the cæca; the coarse residue passing on to the hind-terminal canal.
3. In the cæca the food-pulp is acted upon by secretions of the cells of the cell-nests, which rapidly disintegrate in the work. The fats are emulsified, and a proteolytic ferment transforms the albuminoids into peptones. The filamentous cells take up the emulsified fats, and split them into fatty acids and glycerine within themselves, to be passed on to the blood cells which carry them away, and any excess over immediate requirement is stored up probably in the fat bodies (Cuénot). Other material may also be taken up by these eminently absorbing cells.
4. The remaining digested food passes into the fore-terminal canal, and then into the mid-terminal canal, where it mixes with the coarse food material

and remains for a long time. (In fasting insects after two months, and may be longer, I have found food material there and numberless bacteria). The required soluble products are then selected and absorbed by the epithelial cells, to be passed on to the blood plasma, the setaceous villi and folds playing a large part in gathering what would otherwise escape, while the blood cells within the crypts may absorb, assimilate and transfer the products to other parts.

5. The insoluble residue passes on to the rectum, where mucus, secreted by the cells of the longitudinal rectal glands, is mixed with it and the contents ejected. When an insect is alarmed the black viscid contents of the rectum are ejected with considerable force to serve in defence. The bacteria, which always exist in large numbers in the mid-terminal canal, may render important service in the breaking up of albuminoids, proteids and fats, which have escaped digestion in the mid-intestine (cæca).

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1. Bordas.—L'Appareil digestif des Orthoptères. Ann. Sc. Nat., t. v., 1897, pp. 1–224.
2. Cuénot.—Etudes physiologiques des Orthoptères Arch. Biologie, t. xiv., 1896, pp. 293–341.
3. Miall and Denny.—The structure and life-history of the Cockroach. London 1886.

For full lists of literature see the valuable text-book of Entomology by Prof. A. S. Packard (Macmillan), 1898.

EXPLANATION OF PLATES.

Note.—With the exception of Figs. 1 and 1*a*, all the Figures have been outlined under a camera lucida.

Fig. 1.—Semi-diagrammatic view of the enteric system of Gryllotalpa australis (Erich.), dissected from the left side, and showing positions of the various

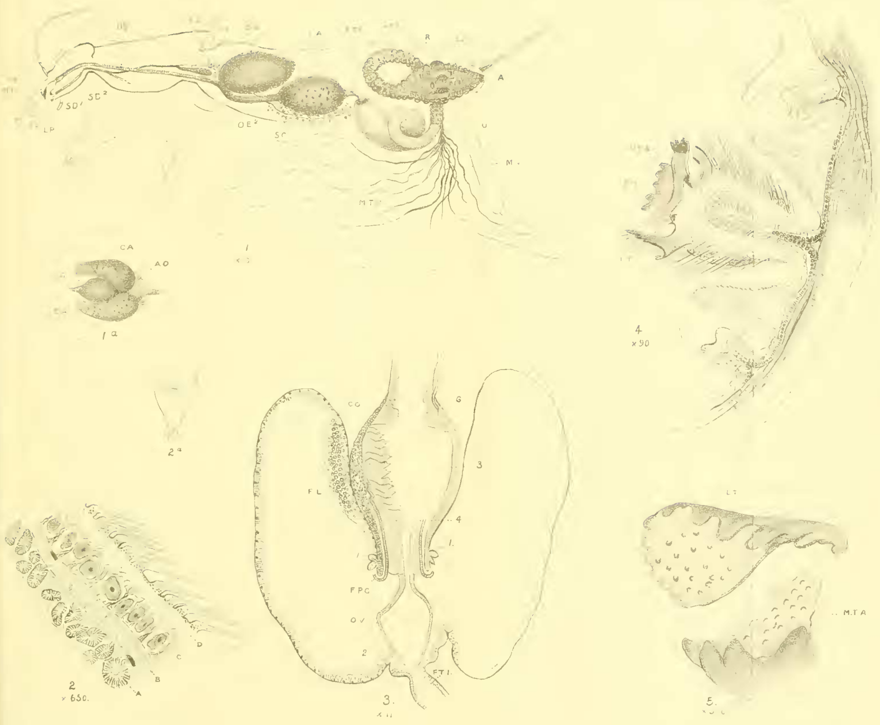
organs in respect to the exoskeleton. × 3. A anus; C.A. one of the cæcal organs; the proventriculus and other cæcum are hidden (see Fig. 1*a*); C.R. crop distended; F.T.C. fore-terminal canal, joining anteriorly with the cæca and posteriorly with M.T.C. the mid-terminal canal; L. lingua (hypopharynx); L.L. labium; L.P. palpus labii; M. mandible; M.P. palpus maxillæ; M.T.C. mid-terminal canal, ending a little anterior to the entrance of the duct of the Malpighian tubes; M.V. Malpighian tubes, only a small number shown, there are two kinds, white and yellow; O.E.[1] fore-gullet; O.E.[2] hind-gullet; R. rectum; R.C. rectal glands; S.D.[1] common duct of salivary glands; S.D.[2] indicates the junction of the right and left median salivary ducts, that leading from the left-side is cut off a little lower down:—S.R. one of the salivary receptacles; U ureter; U.L. labrum.

Fig. 1*a*.—Proventriculus and cæca viewed from ventral aspect × 3. A.O. arborescent organs of Dufour (only the ventral pair shown); C.A. cæca; they compose the whole of the middle intestine (mesenteron); G. proventriculus (gizzard).

Fig. 2.—Longitudinal section of wall of fore-gullet × 650. A radial muscle fibres cut across; B longitudinal muscle fibres; C epithelium cell of hypodermis; D chitinous intima bordered by teeth which are acutely bent and point behind, seen with their thin edge uppermost.

Fig. 2*a*.—An isolated tooth of above with its broad surface uppermost × 650.

Fig. 3.—Median longitudinal section through the proventriculus and mesenteron × 11. C.O. cæcal organs; F.P.C. a food-pulp channel entering into cæca; F.T.I. fore-terminal intestine; F.L. a longitudinal infold of the cæcum cut through the face of cells; O.V. Œsophageal valve — two flaps only show cut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